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THERMAL DESIGN OF THE LIGHTING DEVICE WITH CFD

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Abstract*— This paper suggest a design of 15W CFL bulb, presents a thermal analysis of circular fin in line and heat sinks for a high power CFL lighting system. For enhancing the heat transfer rate, circular fin are one of the most popular choice. The goal of the thermal design of a lighting device is to suggest new design for CFL bulb and to ensure that the temperature of the bulb stays low, the beautification of the bulb will increase. The addition of the fins, will increase the heat transfer to the surrounding. A standard k-ε turbulence model consisting of two transport equations for the turbulent kinetic energy and the turbulent dissipation is used. Results were obtained heat flux for both with and without fins, heat transfer coefficient and how the temperature varies through the blub surfaces.

***Keywords*— 15W CFL Bulb, Ansys, Fins.**

I. INTRODUCTION

CFL bulb are an excellent option for a best alternative light bulbs. CFL glows by phosphor gas by using an electric current. The old CFLs used magnetic ballasts, which usually results delay when it turned on. But now in new CFLs electronic ballasts is used, require a shorter warm up.

A light source is shown in Fig.1. The aim of the project is to make the temperature of the device to stay low. A 15W bulb has been analyzed both in with and without fin. The addition of fins around a light source will increase the heat transfer to the surroundings. The fins are arranged in vertical one by one, totally 12 fins has been used in CFL bulb. The modeling of the discretization the analysis and was done using ANSYS FLUENT 14.0 on Workbench platform. The goal of the present study was to suggest a new design for CFL bulb make the temperature of the device to stay low. A numerical work has been done for getting the result.

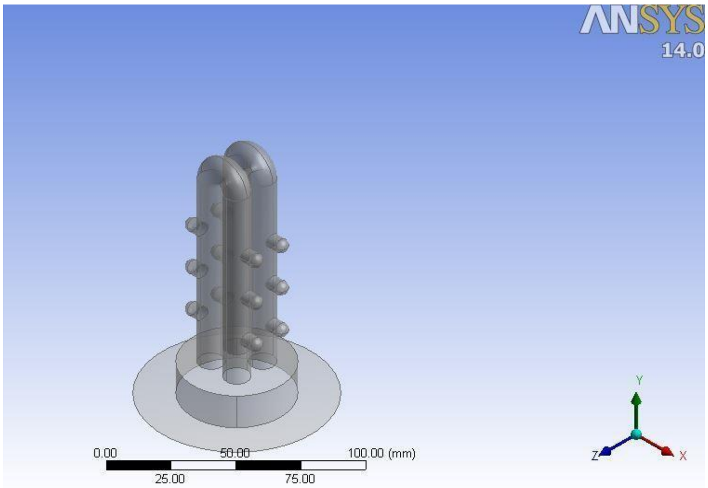

Fig.1 Geometry of a light source

II. NUMERICAL METHOD

A. Conservation Equation

The conservation of mass, momentum and energy equation are used for the present model. The Segregated solver is used and the segregated resolves the governing equation and obtain a converged solution. As the governing equation is coupled and non-linear. For this model SIMPLE scheme is used. SIMPLE algorithm is chosen for all simulation run in current works because it is the basic algorithm.

B. Governing Equation
A. Continuity Equation

$$(\partial\rho/\partial t) + \nabla.(\rho v) = 0 \quad (1)$$

B. Momentum Equation

$$\partial/\partial t(\rho v) + \nabla.(\rho v v) = -\nabla p + \nabla.\tau - (\rho_\infty - \rho)g \quad (2)$$

$$\tau ij = \mu\, eff(\nabla v + \nabla v\, T) \quad (3)$$

C. Energy Equation

$$(D(\rho T)/Dt) = \partial/\partial xi\, [(\mu/Pr + \mu_t/Pr_t)\, \partial T/\partial x_i] \quad (4)$$

$$\mu t = \rho C\mu\, (k^2/\varepsilon) \quad (5)$$

III. GEOMETRY AND DOMAIN

The model is drawn as per the specification given below table 1.

TABLE 1
SPECIFICATION OF LIGHT SOURCE MODEL

Parts Name		Dimensions
Tube surface	Length	98 mm
	Diameter	11 mm
Holder	Height	10
	Diameter	47 mm
Fins	Length	7 mm
	Diameter	6 mm
Domain	Height	150 mm
	Diameter	80 mm
Power		15 W

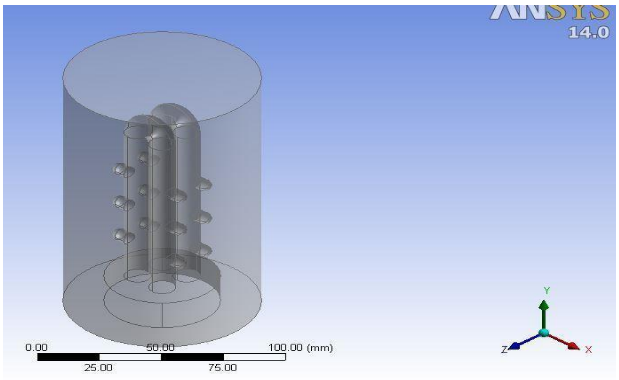

Fig.2 Geometry of a domain

After completion of the model. It was imported to the ANSYS FLUENT 14.0, there the model parts is given naming. The domain has been drawn, then Boolean will be done to remove the solid part of the tube surface and the holder.

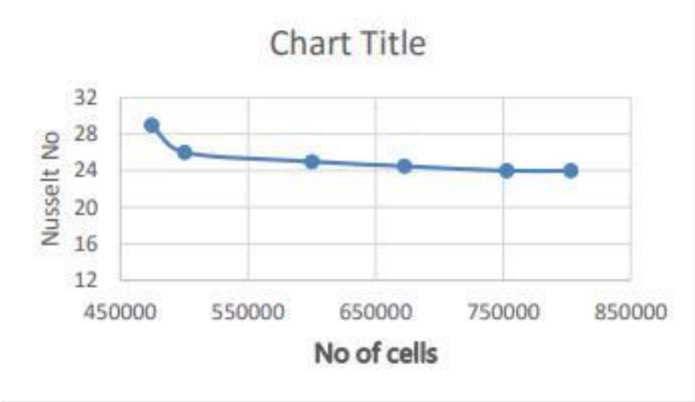

Fig. 3 Grid independency test

The meshing was done for all the cases by using ANSYS FLUENT 14.0, the mesh size for the geometry was calculated by grid independency test. The details shown in the Fig.3. As the Nusselt number goes on decreasing, the grid size is increasing. After some Period of time, the variation in the Nusselt will be less. After that the Nu will be constant. So that grid size is used for the model used here.

IV. NUMERICAL PROCEDURE

The governing equations were integrated over a control volume and then discretized using the finite volume technique to obtain a set of algebraic equations. The algebraic equations result were solved by the algebraic multi grid solver of FLUENT in an iterative manner by providing the boundary conditions.

A. Model of fin tube surface

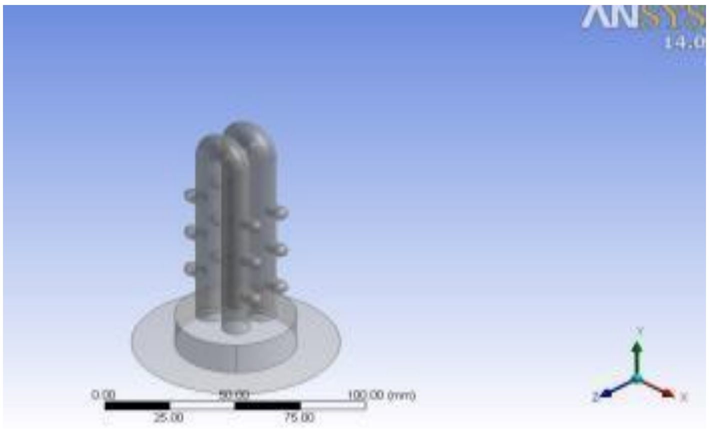

Fig.5 Geometry of the model with fin tube surface

This geometry is drawn in the solid works, the tube and the holder was drawn separately then it was mated in the solid works itself. In this model fin is also drawn with the tube surface. The fins used in this model is circular fin. Each fin distance is 20mm and totally 12 fins is used in this model.

V. RESULT AND DISCUSSIONS

A. Without fin

The geometry without fin was analysed in ANSYS 14, after giving the initial values and boundary conditions then analysed. In the tube surface the temperature is varied in many places, the bottom of the tube is around 338 k temperature. The max temperature is at the side of the tube surface.

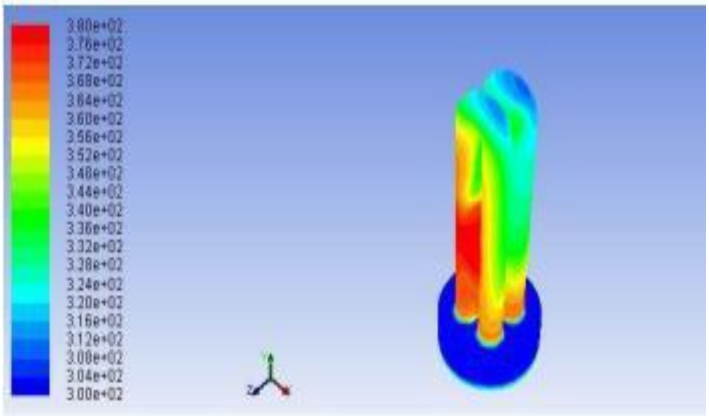

Fig.6 Temperature contour of a tube surface without fin

The heat flux of the tube surface is calculated by using the Eq. (6) & (7)

$L = \pi r + 2(l)$ (6)
$A = 2\pi RL$ (7)

A 15W bulb is used in this project and the heat flux is got for this is 666.6 W/m2 .

B. With fin

After analysing the geometry we have got the temperature contour. In the tube surface the temperature is varied in many places, the bottom of the tube is around 330 k temperature. Using the fins heat transfer can be increased in bulb. So the temperature on the tube surface can be reduced. Here the formula for calculating heat flux is little bit varied. The

equation used for calculating heat flux is shown in Eq. (8), (9), (10) and (11)
$L = \pi r + 2(l)$ (8)

$= 2\pi RL - n(\pi^{2})$ (9)

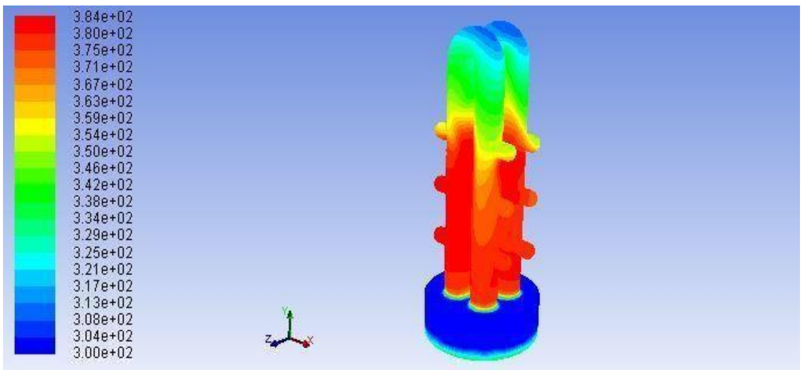

Fig.6 Temperature contour of a tube surface with fin Surface area of fin A

$$A_f = 2\pi(r_{2c}^2 - r_1^2) \times n \quad (10)$$

$$A = \qquad + \quad (11)$$

The area of the fins is calculated separately and then it will be added with the unfinned area value. After that we will get the total surface area value. From that the heat flux is found and the value is 743.67 W/m^2. The value of $T\infty$ is 298.15 K.

$$q = Q/A \quad (12)$$

$$Q = h\,(T1 - T\infty) + \varepsilon\sigma\,(T1^4 - T\infty^4) \quad (13)$$

Where,

Q = heat transfer rate W ε = emissivity is 0.9
σ = 5.67 x 10-8 $w/m^2\ K^4$
The heat transfer coefficient is 4.9 W/m^2.k for without fin and 7.5 W/m^2.k for with fin.

VI. CONCLUSIONS

A 15W CFL bulb was analysed to find out the heat flux for tube surface with and without fin. We are suggesting a new design for CFL bulb from that we can increase the heat transfer rate and also the thermal design of a lighting device temperature of the bulb stays low. According to this thermal analysis method, the heat flux with fin is increased by 10.52%, when it is compared to the heat flux without fin. The heat transfer coefficient with fin is increased by 34.6%, when it is compared to without fin heat transfer coefficient.

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